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Made in China: ERP Post-Implementation Performance in the Chinese Manufacturing Industry

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ABSTRACT

To gain competitive advantages in the global market, many Chinese manufacturing firms have invested heavily in implementing Enterprise Resource Planning (ERP) systems. Evidence shows however that ERP post-implementation performance has varied significantly between firms. This paper aims to investigate such variances in performance in the Chinese manufacturing context, particularly at a plant level. A model developed by Gattiker and Goodhue (2005) has been adapted and extended for our investigation incorporating a survey instrument. Data were collected from 59 Chinese manufacturing firms. The data collected were analyzed using Structural Equation Modeling in association with Partial Least Squares technique. The results shows that the level of interdependence, differentiation between plants, time elapsed since the systems have gone live, high context communication in the Chinese culture, and personal relationship (Guanxi) have significance impact on ERP post-implementation performance.

Keywords

China, Culture, ERP, Post-Implementation Performance, Manufacturing, Plant-Level Analysis

INTRODUCTION

Enterprise Resource Planning systems (ERPs) have been widely adopted among manufacturing firms worldwide (Shi et al 2008). This has also been the case in China during the past decade, as it emerged as a global manufacturing hub. Many Chinese manufacturing firms have thus invested heavily in implementing ERP to gain competitive advantages in the global marketplace (Wang et al. 2005). However, only 10 percent of these firms have realized any ERP related benefits (Yusuf et al 2006). This is significantly less than the reported success rates in western countries (Zhang et al 2005), and is therefore the catalyst for our investigation of factors that influence ERP post-implementation performance among Chinese manufacturing firms at a plant-level analysis that encompasses the role Chinese cultural plays in technology diffusion and performance.

The primary motivator for us is a theoretical gap in the research where the key concepts of post-implementation performance and ERP diffusion in Chinese cultural context intersect. Previous research on ERPs has often focused on vendor selection and

the implementation processes (Ehie and Madsen 2005; Jacobs and Bendoly 2003; Pairat and Jungthirapanich 2005; Botta-Genoulaz et al 2005; Moon 2007; Hakkinen and Hilmola 2008). However, there is minimal work investigating the post-implementation performance of ERP at a plant-level which incorporates a cultural perspective. Thus, this study extends this line of analysis by exploring the role of the Chinese business culture on use of ERPs in the Chinese manufacturing industry.

Previous research has pointed out some prohibitive issues faced by Chinese firms when adopting ERP. Zhang and Wang (2008) assert that overall, there is no significant difference between operating performance of manufacturers that have implemented ERP and those who have not. This could be due to difficulties often encountered in ERP adoption in China include lack of top management support, cost and time issues, cultural differences, technical complexity, lack of professional personnel and organizational resistance (Yusuf et al, 2006). Consistent with the global ERP research, lack of top management support is particularly critical for ERP implementation in China (Xin and Wenji, 2007).

Another important factor is the proposition that Information Systems (IS) have built-in values biases reflecting cultural values in which they were developed, a cultural misfit is likely to occur if an IS developed in one culture is adopted by organizations in another culture (Burton and Obel 2004; Kangas 2003). ERPs were originally developed in western countries and therefore, these systems have emerged from western cultural values, which may impact their effective implementation and use in non-western contexts. Avison and Malaurent (2007) assert that cultural differences could even override technical considerations in the global rollout of ERP systems. They argue that the main cultural barriers of ERP implementation in the Chinese environment are: language and communication difficulties (such as 'losing face' and not understanding the ERP instructions in English), economic issues (such as the unexpected local reporting obligations), and structural issues (such as the strong respect to the organizational hierarchy).

To address the above knowledge gap, we pose the following research question: *'What factors affect the post-implementation performance of ERP system among the Chinese manufacturing firms?'* Consequently, this research adopted a research model originally proposed by Gattiker and Goodhue (2005) for analyzing the issues affecting ERP post-implementation performance among the US manufacturing firms. To serve the purpose of this study, the model was extended by incorporating Chinese cultural factors. A questionnaire was used to gauge the impact of Chinese culture on the post-implementation performance of ERP among Chinese manufacturing firms at a plant-level. The following section presents a review of the ERP post-implementation model by Gattiker and Goodhue (2005) and addresses the need for incorporating cultural factors.

THE DEVELOPMENT OF RESEARCH MODEL AND HYPOTHESES

Gattiker and Goodhue's Model

Many studies have investigated ERP post-implementation performance (e.g. Calisir 2004; Hakkinen and Hilmola 2008; Nicalaou 2004; Nicolaou and Bhattacharya 2008; Yu 2005). Of particular relevance to our project is the study conducted by Gattiker and Goodhue (2005) who introduced a research model (Figure 1) to investigate the post-implementation performance of ERP systems at a plant-level in the US manufacturing industry. They argue that ERP may bring a firm more profit and improved performance, however, this does not happen automatically and there must be more intermediate effects that lead to those observable overall benefits. Intermediate benefits are the pathways through which ERP can enable firms to achieve higher profits and gain greater overall ERP-related results. They propose that intermediate benefits need to be investigated since an overall or aggregate-level impacts cannot occur directly without the existence of intermediate impacts. These intermediate benefits include efficiency generated by integrating business processes and improved coordination among subunits of a firm. Thus, the two intermediate benefits identified in the original model are task efficiency and coordination improvement.

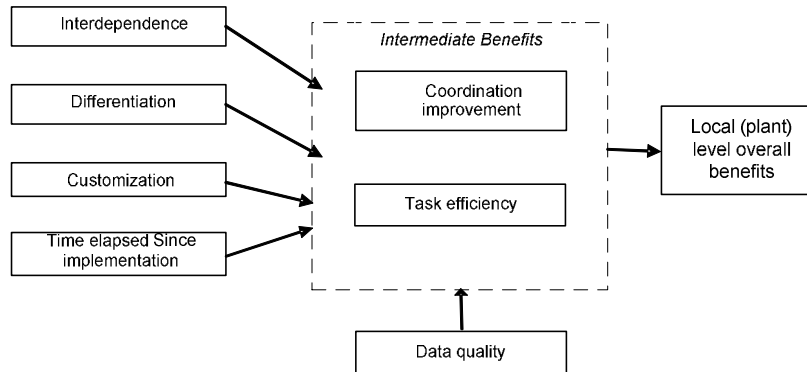


Figure 1: Gattiker and Goodhue (2005) Model

Extended Research Model

The Gattiker and Goodhue's model (2005) was extended by incorporating Chinese cultural values for the purpose of this study. The proposed research model is shown in Figure 2. Although in the original model, coordination improvement and task efficiency constructs are proposed as ERP intermediate benefits, while data quality construct is treated as a control variable, in the extended model, data quality is included as a part of intermediate benefits. This research takes a view that data quality can be viewed as benefits of ERP (Greef et al 2004). Furthermore, the customization construct is dropped out in this research as Gattiker and Goodhue (2005) did not find a significance impact in the original model.

Importantly, two Chinese cultural factors are introduced to the model. Chinese culture is rooted in Confucianism. Confucianism is a social and moral philosophy based on life by Kong Fu Zi (551-479 BC), who was subsequently called Confucius by Jesuit missionaries and his disciples. Confucianism emphasizes humanistic, harmonious, introspective, and knowledge-oriented ways of life which have continuously influenced the Chinese public and formed the basis of Chinese cultural values (Chhokar et al 2007). Therefore, Chinese cultural values on communication and personal relationships that may impact the post-implementation performance of ERP systems in China are included and discussed below. The development of the research hypotheses are presented in the following sub-sections.

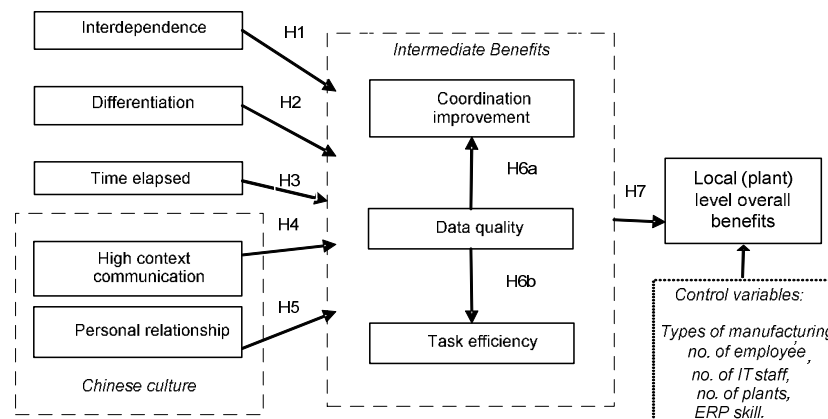


Figure 2: Extended research model

Interdependence

Interdependence is required to achieve integration of an ERP system (Gattiker and Goodhue 2005). Bendoly et al. (2006) suggest that codified information systems that are designed to facilitate the information-sharing capabilities are especially

beneficial when system users are in highly interdependent organizational settings. They also assert that in a Chinese collectivist culture, the communication capabilities of ERP systems are highly regarded, so when task interdependence increases, the management-assessed usefulness of ERP systems also increases. Given the importance of interdependence in the Chinese cultural context, the construct is included in the model. It refers to the extent that activities in one unit are affected by activities in other units in an organization. Therefore, it is proposed that:

- H1a: Interdependence has a positive effect on coordination improvement within Chinese manufacturing firms.
- H1b: Interdependence has a positive effect on data quality within Chinese manufacturing firms.
- H1c: Interdependence has a positive effect on task efficiency within Chinese manufacturing firms.

Differentiation

The differentiation construct is defined as an inherent property of an individual plant (Gattiker and Goodhue 2005). It refers to a level of difference between a plant and an organizational norm on a number of key characteristics in terms of production and operation processes (e.g. the volume and variety of products produced). When a plant's operation process is significantly different from other plants in the same organization, difficulties in utilizing the ERP system are more likely to be encountered since the system allows limited flexibility to suit its particular situation (Gattiker and Goodhue 2002, Jacobs and Bendoly 2003). Therefore, it is hypothesized that:

- H2a: Differentiation has a negative effect on coordination improvement within Chinese manufacturing firms.
- H2b: Differentiation has a negative effect on data quality within Chinese manufacturing firms.
- H2c: Differentiation has a negative effect on task efficiency within Chinese manufacturing firms.

Time Elapsed after ERP Implementation

Bendoly and Jacobs (2005) suggests that time is a critical prerequisite for extracting value from ERP systems. Time lag, therefore, must be considered when evaluating the performance of IT investment (Lee and Kim 2006). Nicolaou (2004) found that there is a time lag of at least two years before ERP adopters began to reap the differential positive financial benefits from the systems, while Gattiker and Goodhue (2005) suggest that ERP impacts are expected to increase with time, but at a decreasing rate. Therefore, it is hypothesized that:

- H3a: Time elapsed has a positive effect on coordination improvement within Chinese manufacturing firms.
- H3b: Time elapsed has a positive effect on data quality within Chinese manufacturing firms.
- H3c: Time elapsed has a positive effect on task efficiency within Chinese manufacturing firms.

High context Communication

This study proposes Chinese culture and its' orientation to communication may influence the use of ERP systems in China. Hall (1976) takes the view that culture can be classified into high-context (HC) and low-context (LC) culture/communication. Examples of HC countries include China, Japan, Malaysia and Mexico, while Australia, England, Germany and Sweden are considered as low-context cultures. In HC cultures, messages have little meaning without an understanding of the surrounding context. Individuals from HC cultures prefer more historical information and more subjective opinions. This may include information about the backgrounds of the people involved, previous decisions, and the history of the relationship. In contrast, individuals from LC cultures prefer more objective and 'fact-based' information and are more likely to consider the factual message as sufficient.

Chinese people prefer communication media that are able to carry a great deal of contextual information such as face-to-face communication. This conflicts with the characteristic of ERP systems, which do not usually convey 'richness' in meaning. Thus, this study proposes the following hypotheses:

- H4a: High context communication has a negative effect on coordination improvement within Chinese manufacturing firms.
- H4b: High context communication has a negative effect on data quality within Chinese manufacturing firms.
- H4c: High context communication has a negative effect on task efficiency within Chinese manufacturing firms.

Personal Relationship/Guanxi

One of most representative of the Chinese cultural values is the concept of Guanxi which loosely translates to ‘personal relationship’ in English. Guanxi refers to the act of drawing on connections in order to secure personal favors (Luo 2007). It imposes implicit mutual obligations, assurances, and understanding on Chinese individuals and has a great influence on Chinese attitudes toward long-term social and business relationships. Generally, Guanxi implies a continued exchange of favors in interpersonal relationships, so it extends beyond mere friendship. It can be argued that such interpersonal connection exists, to some extent, in every human society; however, Guanxi plays a comparatively more fundamental role in the daily life of the Chinese society (Luo 2007). Of significant relevance to our project is a study conducted by Marble and Lu (2007) which concluded that ERP systems adopted in China. They assert that successful ERP systems implementation need to support the Chinese Guanxi-based business practices. Therefore, we propose the following hypotheses:

H5a: Personal relationship has a positive effect on coordination improvement within Chinese manufacturing firms.

H5b: Personal relationship has a positive effect on data quality within Chinese manufacturing firms.

H5c: Personal relationship has a positive effect on task efficiency within Chinese manufacturing firms.

Data Quality

Data quality refers to accuracy and relevancy of data generated by ERP systems (Gattiker and Goodhue 2005). Vosburg and Kumar (2001) assert that data quality is essential to many benefits derived from ERP. In essence, ERPs play the role of an information highway that connects all planning levels and links various decision support systems to a central repository of data (Puigjaner and Heyen 2006). Therefore, data quality is a central element of a successful ERP. Hence, it is hypnotized that:

H6a: Data quality has a positive effect on coordination improvement within Chinese manufacturing firms.

H6b: Data quality has a positive effect on task efficiency within Chinese manufacturing firms.

Overall benefits at plant-level

According to Gattiker and Goodhue (2005), overall benefits of ERP adoption can be measured at an organization level (overall or average level of interdependence of an organization) or at a subunit level (interdependence between a particular plant and other plants of the organization). Ake et al (2003) assert that many companies have obtained suboptimal benefits from their ERP systems because they lack an understanding on how ERP systems should be applied at the plant-level. This view is supported by Gattiker and Goodhue (2005). Therefore, this study hypothesis that:

H7a: Coordination improvement has a positive effect on overall benefits at a plant-level within Chinese manufacturing firms.

H7b: Data quality has a positive effect on overall benefits at a plant-level within Chinese manufacturing firms.

H7c: Task efficiency has a positive effect on overall benefits at a plant-level within Chinese manufacturing firms.

METHODOLOGY

Quantitative empirical data were collected through survey questionnaire between August and September 2008. It was administrated in China by one of the authors. The survey was formerly translated to the Chinese language and the translated version was verified by bilingual linguistic experts. The paper-based surveys were sent to 612 senior plant managers who were involved in the daily operations of ERP systems in 59 Chinese manufacturing firms. A seven-point Likert scale was used to measure their attitudes to ERP performance. The response rate of valid surveys was 39 percent at the firm level and 13 percent at the plant level. These manufacturing firms were located in three provinces namely: Jiangsu province (45.57 percent), Zhejiang province (29.11 percent) and Shanghai (25.32 percent). These three regions are located in southern part of China, which is renowned for its high concentration of manufacturing firms.

Data collected were analyzed using Structural Equation Modeling (SEM) with Partial Least Squares (PLS) technique. The model was operationalized and analyzed in PLS-graph Version 3.0. The PLS approach was preferable for this study because it provides a better prediction capability and it is effective in the analysis of a high complexity model with small sample size compared to a large number of independent variables. In addition, it imposes no requirement of a normal distribution

assumption which suits the nature of the data collected. Importantly, the measurement model was tested to ensure the reliability and validity of the survey instrument and such validity and reliability of all measurement items and constructs were satisfied.

The majority of the respondents were Small to Medium Enterprises (SMEs) consisting of: 22.8 percent of small enterprises, 64.6 percent of medium enterprises, while large organization constituted 12.7 percent. In addition, about 50 percent of the respondent had an average of 2-7 plants per firm; 54.4 percent of the respondent indicated that they have an average of 100 full time staff per plant; and 68.4 percent had between 1-5 full time IT staff per plant. Interestingly, 67.1 percent used local ERP applications which were produced by Chinese firms, while 29.1 percent used international ERP applications. About 43 percent had implemented and used ERP systems for 1-3 years; 32.9 percent for 3-5 years; and 20.3 percent for more than 5 years. The next section presents a detailed discussion of the results of the structural model.

RESULTS AND DISCUSSION

Figure 3 presents the results of the structural model generated by PLS. The predictiveness of the model can be assessed by the R^2 of the dependent constructs. The results show that R^2 of the overall performance at plant-level is 0.614, which indicates that intermediate benefits (coordination improvement, data quality and task efficiency) accounted for 61.4 percent of the variance of the construct. Among the intermediate benefits constructs, data quality highly contributes to the overall performance construct (0.414 of path coefficient), followed by task efficiency (0.325) and coordination improvement (0.214). In addition, the task efficiency construct has the highest R^2 (0.625) compared to coordination improvement ($R^2 = 0.418$) and data quality ($R^2 = 0.497$).

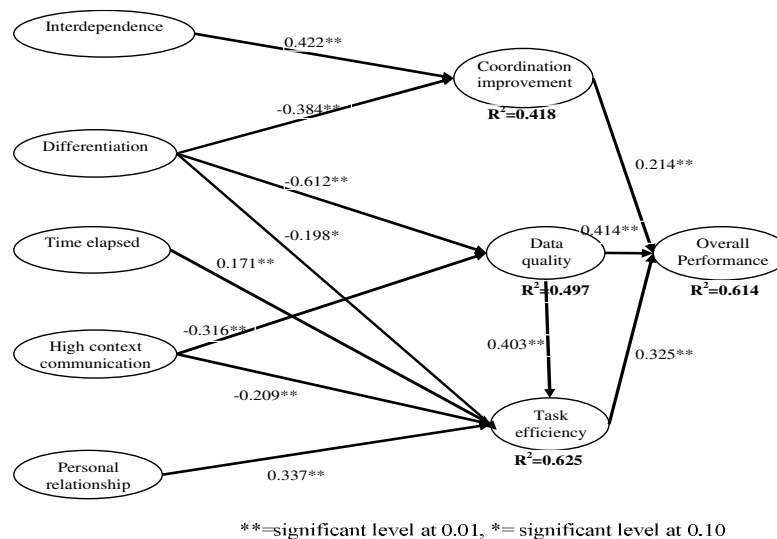


Figure 3: Structural model results

Table 1 presents the statistical outcome obtained through the bootstrapping procedure of the PLS Graph (that is actual effect, path coefficient, T-statistics, and significance level). In addition, a power analysis was conducted by using SPSS version 13 to ensure the confidence level of the rejection of the null hypothesis. The results of the power analysis indicated that all the power scores achieved the cut off point of 0.80. Thus, the rejection of the null hypothesis was valid.

Specifically, this research proposes that interdependence between the plants in a manufacturing firm influences the intermediate benefits gained from ERP systems. The results of this study support hypotheses 1a and reject hypotheses 1b and 1c. This indicates that interdependence has a significant positive effect on coordination improvement. The path coefficient between interdependence is 0.433 at a 99 percent significance level. This implies that the more interdependence between plants in a firm, a higher coordination level is likely to be achieved by using ERP. This finding is consistent with the results in prior studies (e.g. Gattiker and Goodhue 2005). As the level of interdependence increases, firms must spend more time and effort on improving coordination mechanisms that are required to integrate the enterprise system. In other words, when the

subunits (plants) are interdependent, highly integrated mechanisms would be beneficial as they can facilitate the information exchange across the subunit boundaries within the organization.

	Actual Effect	Path Coefficient	T-statistics	Significance Level	Power*
Interdependence					
Coordination	+	0.422	4.427	0.01	
Data Quality	+	0.033	0.347	Not significant	0.60
Task Efficiency	+	0.060	0.775	Not significant	0.77
Differentiation					
Coordination	-	0.384	2.694	0.01	
Data Quality	-	0.612	6.259	0.01	
Task Efficiency	-	0.198	1.623	0.10	
Time Elapsed					
Coordination	-	0.097	1.526	Not significant	0.82
Data Quality	-	0.010	0.178	Not significant	0.85
Task Efficiency	+	0.171	2.134	0.01	
High Context Communication					
Coordination	-	0.196	1.512	Not significant	0.91
Data Quality	-	0.316	2.704	0.01	
Task Efficiency	-	0.209	2.108	0.01	
Personal Relationship (Guanxi)					
Coordination	+	0.053	0.469	Not significant	0.95
Data Quality	+	0.036	0.310	Not significant	0.90
Task Efficiency	+	0.337	2.629	0.01	
Data Quality					
Coordination	-	0.015	0.099	Not significant	0.99
Task Efficiency	+	0.403	3.243	0.01	
Overall Performance					
Coordination	+	0.214	2.400	0.01	
Data Quality	+	0.414	3.222	0.01	
Task Efficiency	+	0.325	3.020	0.01	

* Computed with $\alpha=0.5$ and only reported for tests with non-significant results

Table 1: Summary of path coefficient test results

The level of differentiation between plants within a firm is found have a significant and negative impact on the coordination improvement and the data quality at 99 percent significance level, and task efficiency at 90 percent significance level. This implies that a higher level of differentiation between plants results in lower intermediate benefits. Differentiation between plants has the most impact on data quality (0.612 of path coefficient), followed by coordination improvement (0.384) and

task efficiency (0.198). This result is in line with previous research, for example, Burton and Obel (2004) also indicated that a manager prefers an organization where jobs and functions are well defined and the manager knows what each subunit and individual does; but with a high level of differentiation, it becomes more difficult for managers to coordinate and control the activities of the organization. Gattiker and Goodhue (2005) also assert that ERPs can create operational difficulties for a subunit whose products and production processes are different from other subunits within the same organization.

Moreover, the results demonstrate that time elapsed since ERP implementation has a significant impact on the task efficiency construct. Thus, hypothesis 3c is accepted, while hypotheses 3a and 3b are rejected. This implies that the longer time has elapsed since the ERP has gone live, the higher the task efficiency. This result conforms to the finding of Gattiker and Goodhue (2005). In addition, Bendoly and Jacobs (2005) also suggested that time itself is a critical prerequisite for extracting value from ERP and that value derived from using ERP is consistent with the time spent on using the system.

Regarding the of high context (HC) communication characterizing the Chinese culture, hypothesis 4a is rejected, while hypotheses 4b and 4c are accepted. The results of this study therefore demonstrate that HC has a significant impact on the intermediate benefits in terms of the data quality and the task efficiency. Similarly, Beyerlein et al (2005) assert that people in HC cultures rely on situational cues for meaning when communicating with others, hence nonverbal cues, such as position or status, convey messages more powerfully than do spoken or written words. In ERP systems, data are codified and information processing is computerized, making the ERP a less effective communication medium from the Chinese perspective, thus the perceived intermediate benefits are low.

Interestingly, the results also indicate that personal relationship/Guanxi has a significant impact on the task efficiency (0.337 of path coefficient). Thus, hypothesis 5c is accepted. It can be argued that since using Guanxi enforces a preferred way of communicating in the Chinese culture, people would rely more on the information gained through their personal relationship than that provided via ERP systems. However, the analysis proves that Guanxi leads to higher task efficiency when using ERP systems. It may be possible that employees use Guanxi to stimulate the use of ERP systems, as Liang et al (2007) asserted that normative pressures which are exerted by top managers' personal relationships with their counterparts in other organizations and officials in various government agencies could impact the level of ERP usage. Moreover, Li et al (2007) considered trust as a fundamental factor to information sharing in an organization. Since personal relationship/Guanxi is a trust-based concept, it can indeed stimulate the use of ERPs. Therefore, Guanxi could lead to better utilization and acceptance of ERP in an organization.

Furthermore, this study further explores the relationship among intermediate benefits constructs. The results of this study indicate a significant relationship between the data quality and task efficiency constructs. Thus, hypothesis 6b is accepted and could be validated by Starinsky's (2003) assertion that data quality is a fundamental principle which determines the success of an organization when implementing ERP systems. Olson (2003) also takes the view that better data quality provided by ERPs can increase the task efficiency among plants within an organization.

Hypotheses 7a, 7b and 7c are all accepted. Coordination improvement, data quality and task efficiency have significant impact on the overall performance. These three factors together constitute a substantial amount ($R^2 = 0.614$) of the variance of plant-level overall benefit. Among these factors, data quality has the most impact on the overall performance (0.414 of path coefficient), followed by task efficiency (0.325) and coordination improvement (0.214). This implies that data quality is the most influential factor affecting the overall performance of ERPs, while coordination improvement is least. This reinforces the importance of data quality in reaping the targeted benefits from ERPs.

DISCUSSION AND CONCLUSION

This research has investigated the factors affecting ERP post-implementation benefits at plant-level in the Chinese manufacturing industry. This research adapted Gattiker and Goodhue (2005) model, which was developed to investigate a similar issue in the US manufacturing context. The research model was extended to suit the research context by incorporating Chinese cultural factors. The research found that interdependence, differentiation, time elapsed since implementation, high context cultural and personal relationship can explain, to a significant extent, why ERP post-implementation performance varies from one plant to another in the Chinese manufacturing sector. Importantly, Chinese cultural values have proven to have a substantial impact on the intermediate benefits of ERP systems. High context communication adversely affects data quality and task efficiency, thus, it is a prohibitive factor for ERPs in China. Surprisingly, personal relationship/Guanxi was found to be a contributing factor to task efficiency. This implies that using Guanxi may be an effective way to improve the utilization and performance of ERP systems in an organization.

In addition to Chinese cultural factors, the findings of this research are largely consistent with the results of the original Gattiker and Goodhue's (2005) model. To improve work coordination among plants, firms need to consider the

interdependence and differentiation between plants when implementing ERP systems. In addition, differentiation is also an influential factor in determining the data quality and task efficiency in Chinese manufacturing firms. Firms should ensure that the business processes and salient policies between plants are synchronized and aligned. Furthermore, the influence of time elapsed on task efficiency implies that an adequate program of organizational learning and training to use ERP systems should be encouraged. The more time and experience that users have with ERPs, the better performance outcomes can be expected.

One of the limitations of this study is the scope of the unit of analysis. This study is limited by concentrating only on the performance of ERPs in the manufacturing industry. In doing so, this study may restrict its findings to this particular industry context. Caution therefore should be taken when generalizing the conclusions. Hence, future research may extend this study by using a larger sample size, a variety of industrial contexts and a variety of countries. Another limitation is the fact that three Chinese provinces were targeted in the study. Although these three provinces have a stronger manufacturing base, an extension of this study to other provinces may be beneficial for a complete understanding of the entire Chinese context.

Given the growing importance of the Chinese manufacturing industry for both domestic and global consumption and operations, and the fundamental role that ERPs could play in maintaining such efficiencies, studies in this context are particularly valuable to businesses as well as governments around the globe.

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